MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2018/2019

PTH0016 – MODERN PHYSICS & THERMODYNAMICS

(All Sections / Groups)

7 MARCH 2019
9.00 A.M – 11.00 A.M.
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This question paper consists of 7 printed pages including cover page.
2. Attempt **ALL** questions. All questions carry equal marks and the distribution of the marks for each question is given.
3. Please print all your answer in the Answer Booklet provided.
4. All necessary workings MUST be shown.

ANSWER ALL QUESTIONS.

QUESTION 1 (15 MARKS)

(a) Consider light traveling from one medium into another medium with a different index of refraction.

(i) Does its frequency change? [1 mark]
(ii) Does its speed change? [1 mark]
(iii) Does its direction change? [1 mark]
(iv) Does its wavelength change? [1 mark]

(b) A wide-angle mirror in a grocery store is made from a section of a spherical surface whose radius of curvature is 0.80 m. A person with a height of 1.69 m is standing 3.0 m in front of the mirror.

(i) How far is the image of the person formed behind the mirror? [2 marks]
(ii) Determine the height of the image? [1 mark]

(c) **Figure Q1 (c)** shows a parallel-sided of glass is formed by two prisms with same angle but different indices of refraction. The index of the first prism n_1 = 1.52 and that the second prism is n_2 = 1.77. If a ray of light is incident on the first prism as shown in the diagram, determine the angle that the emerging ray will make with the incident beam. [8 marks]

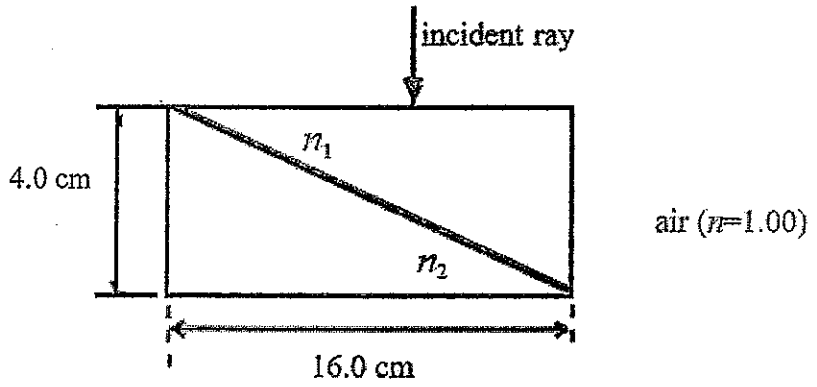

Figure Q1 (c)

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QUESTION 2 (10 MARKS)

a) Two different monochromatic light sources, one green (570 nm) and one violet (425 nm), are used in a photoelectric effect experiment. The metal surface has photoelectric threshold frequency of 6.2×10^{14} Hz.

(i) Calculate the frequencies of the green and violet light. [2 marks]

(ii) Determine whether both sources able to eject photoelectrons from the metal. Explain your answer. [1.5 marks]

(iii) Calculate the amount of energy required to eject an electron from the metal surface in eV. [1.5 marks]

(b) A hydrogen atom undergoes a transition from the third excited state to the second excited state.

(i) Find the energy of the emitted photon in joules. [2 marks]

(ii) What is the wavelength of the emitted photon? [2 marks]

(iii) For an unexcited hydrogen atom, what is the energy required (in eV) to free the electron in the atom? [1 mark]

QUESTION 3 (10 MARKS)

(a) The number of remaining radioactive nuclei N is $N(t)=N_0e^{-\lambda t}$ where N_0 is the initial number of radioactive nuclei and λ is the decay constant. Show that $N(t)=N_0e^{-\lambda t}$ can be expressed as $N(t)=N_0\left(\frac{1}{2}\right)^{\frac{t}{t_{1/2}}}$ where $t_{1/2}$ is the half-life of the radioactive substance. [3 marks]

(b) (i) Find the binding energy per nucleon in electron volts of the following nuclei: $^{59}_{27}\text{Co}$ and $^{24}_{12}\text{Mg}$. The atomic masses of $^{59}_{27}\text{Co}$, $^{24}_{12}\text{Mg}$ and $^{1}_{1}\text{H}$ are 58.933194 u, 23.985042u, and 1.007825 u respectively while the mass of a neutron is 1.008665 u. [6 marks]

(ii) Which nucleus is more stable, $^{59}_{27}\text{Co}$ or $^{24}_{12}\text{Mg}$? [1 mark]

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QUESTION 4 (15 MARKS)

(a) Briefly define heat. [2 marks]

(b) A 100-g aluminium disk at 200°C is placed in 300 cm^3 of ethyl alcohol at 10.0°C, then quickly removed. The aluminium temperature is found to have dropped to 110°C. What is the new temperature of the ethyl alcohol? The specific heat capacities of aluminium and ethyl alcohol are 900 $Jkg^{-1}K^{-1}$ and 2400 $Jkg^{-1}K^{-1}$ respectively. The density of ethyl alcohol is 790 kg/m^3. [5 marks]

(c) The temperature of 0.15 mol of an ideal gas is held constant at 77.0°C while its volume is reduced 25% of its initial volume. The initial pressure of the gas is 1.25 atm.

(i) Determine the work done by gas. [4 marks]

(ii) What is the change in internal energy of the gas? [2 marks]

(iii) Calculate the amount of heat involved in the process. Hence, determine if the gas absorbs or releases heat. [2 marks]

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APPENDIX I

LIST OF PHYSICAL CONSTANTS

Electron mass,	m_e	=	9.11×10^{-31} kg
Proton mass,	m_p	=	1.67×10^{-27} kg
Neutron mass,	m_n	=	1.67×10^{-27} kg
Magnitude of the electron charge,	e	=	1.602×10^{-19} C
Universal gravitational constant,	G	=	6.67×10^{-11} N.m^2 / kg^2
Universal gas constant,	R	=	8.314 J/mol.K
Hydrogen ground state,	E_0	=	13.6 eV
Boltzmann's constant,	k_B	=	1.38×10^{-23} J/K
Compton wavelength,	λ_c	=	2.426×10^{-12} m
Planck's constant,	h	=	6.63×10^{-34} J.s
		=	4.14×10^{-15} eV.s
Speed of light in vacuum,	c	=	3.0×10^8 m/s
Rydberg constant,	R_H	=	1.097×10^7 m^{-1}
Acceleration due to gravity of earth,	g	=	9.80 m/s^2
1unified atomic mass unit,	1 u	=	931.5 MeV/c^2
		=	1.66×10^{-27} kg
1 electron volt,	1 eV	=	1.60×10^{-19} J
Avogadro's number,	N_A	=	6.023×10^{23} mol^{-1}
Threshold of intensity of hearing,	I_0	=	1.0×10^{-12} W/m^2
Coulomb constant,	$k = \frac{1}{4\pi\varepsilon_0}$	=	9.0×10^9 N.m^2 /C^2
Permittivity of free space,	ε_0	=	8.85×10^{-12} C^2/N.m^{-2}
Permeability of free space,	μ_0	=	$4\pi \times 10^{-7}$ T.m/A
1 atmosphere pressure,	1 atm	=	1.0×10^5 N/m^2
		=	1.0×10^5 Pa
Wien's displacement constant		=	0.2898×10^{-2} m.K
Speed of Sound in Air		=	343 m/s
Refractive index of air/vacuum	n	=	1.0
Earth: Mass,	M_E	=	5.97×10^{24} kg
Radius (mean),	R_E	=	6.38×10^3 km
Moon: Mass,	M_M	=	7.35×10^{22} kg
Radius (mean),	R_M	=	1.74×10^3 km
Sun: Mass,	M_S	=	1.99×10^{30} kg
Radius (mean),	R_S	=	6.96×10^5 km
Earth-Sun distance (mean),		=	149.6×10^6 km
Earth-Moon distance (mean),		=	384×10^3 km

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APPENDIX II

LIST OF FORMULAS IN MODERN PHYSICS & THERMODYNAMICS

$$\sin\theta_1 + \sin\theta_2 = 2\sin\left(\frac{\theta_1+\theta_2}{2}\right)\cos\left(\frac{\theta_1-\theta_2}{2}\right)$$

$$\cos\theta_1 + \cos\theta_2 = 2\cos\left(\frac{\theta_1+\theta_2}{2}\right)\cos\left(\frac{\theta_1-\theta_2}{2}\right)$$

$$\sin\left(\theta+\frac{\pi}{2}\right) = \cos\theta$$

$\sin\theta \approx \tan\theta \approx \theta$ *rad* for small angles

$D(x, t) = D_M \sin(kx \pm \omega t \pm \phi)$

$$v = \sqrt{\frac{F_T}{\mu}} \qquad v = \sqrt{\frac{\text{elastic property of the medium}}{\text{inertia property of the medium}}} \qquad v = (331 + 0.60T) \qquad v = f\lambda$$

$$f_n = \frac{nv}{2L} \qquad f_n = \frac{nv}{4L} \qquad \lambda_n = \frac{2}{n}L \qquad f' = f\left(\frac{v \pm v_o}{v \mp v_s}\right)$$

$$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f} \qquad \frac{1}{f} = (n-1)\left\{\frac{1}{R_1} + \frac{1}{R_2}\right\} \qquad f = \frac{R}{2}$$

$$d\sin\theta = m\lambda \qquad d\sin(\theta) = \left(m+\frac{1}{2}\right)\lambda \qquad a\sin(\theta) = n\lambda$$

$$\lambda_m . T = 0.2898 \times 10^{-2} \qquad I(\lambda, T) = \frac{2\pi c k_B T}{\lambda^4}$$

$$E_n = -\frac{mk^2e^4}{2\hbar^2}\left(\frac{1}{n^2}\right) \qquad r_n = \frac{\hbar^2}{mke^2}n^2 \qquad L = mvr_n = n\hbar$$

$$\frac{1}{\lambda} = R_H\left[\frac{1}{n_i^2} - \frac{1}{n_f^2}\right] \qquad \frac{1}{\lambda} = \frac{mk^2\ Z^2e^4}{4\pi\ c\hbar^3}\left[\frac{1}{n_f^2} - \frac{1}{n_i^2}\right] \qquad \lambda = \frac{h}{p}$$

$$R = R_0e^{-\lambda t} \qquad \lambda = \frac{\ln 2}{T_{1/2}} \qquad Q = (M_X - M_Y - M_\alpha)\ c^2$$

$$pV = nRT \qquad k = \frac{R}{N_A} \qquad N = N_0e^{-\lambda t}$$

$$\frac{\Delta Q}{\Delta t} = -kA\frac{\Delta T}{\Delta L} \qquad \frac{\Delta Q}{\Delta t} = e\sigma AT^4 \qquad \frac{\Delta Q}{\Delta t} = IeA\cos(\theta)$$

$$\overline{KE} = \frac{1}{2}m\bar{v}^2 = \frac{3}{2}kT \qquad U = \frac{3}{2}nRT$$

$$Q = \Delta U + W \qquad W = \int dW = \int_{V_i}^{V_f} P\,dV \qquad W = P\Delta V$$

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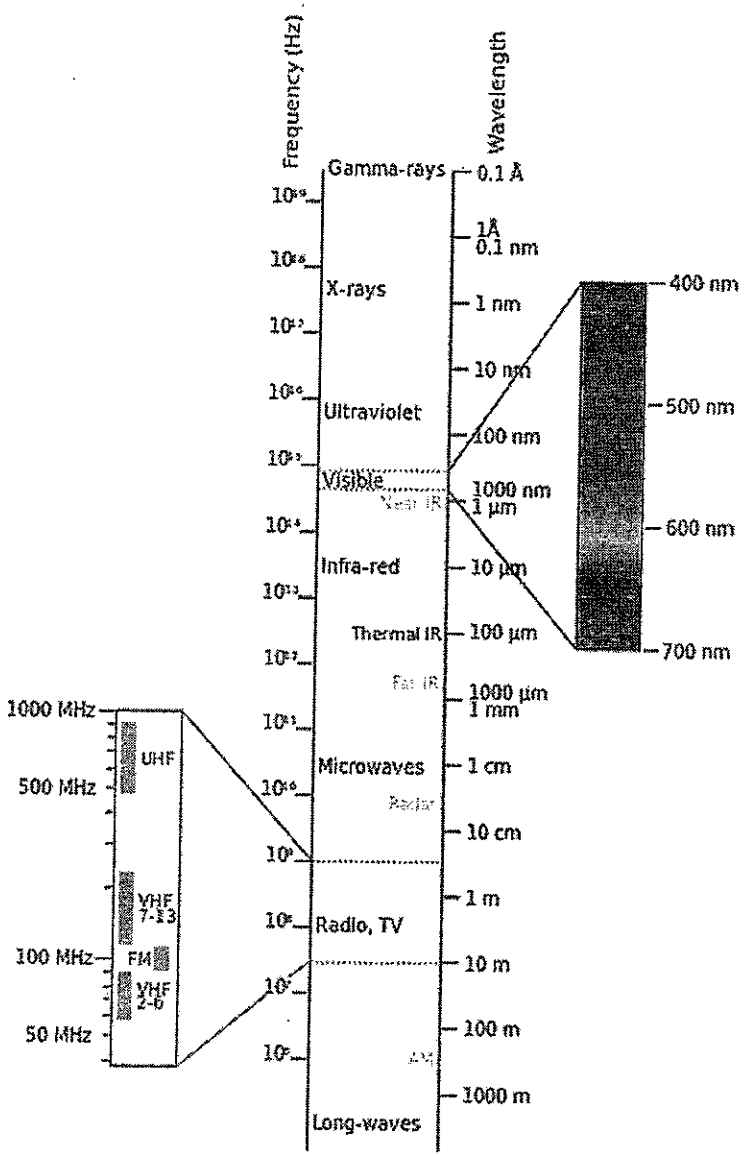
APPENDIX III



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